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**THE STUDY OF A NEW PARRNe EXPERIMENTAL AREA USING
AN ELECTRON LINAC CLOSE TO THE ORSAY TANDEM**

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Abstract

The Production of neutron-rich radioactive nuclei through fission is currently prime of research interest for the future radioactive beam facilities. For example in the EURISOL[1] project, photo-fission and fast neutron induced fission are proposed. The photo-fission cross-section for ^{238}U is about 0.16 barn (against 1.6 barn for fast neutrons of 40 MeV) but the conversion electrons/gammas is much more efficient than that of deuterons/neutrons. It was necessary, to test this new method of production, to carry out, in equivalent conditions, an experiment of the type PARRNe-1 using a 50 MeV electron beam. In April 2001, production of fission fragments induced by gammas proved to be successful. Bremsstrahlung gamma rays were produced by the few nA-50 MeV electron beam delivered by the CERN LEP Injector Linac (LIL). This promising alternative has stimulated the study of a new experimental area at IPNO based on an electron Linac close to the Tandem, through a collaboration with LAL and CERN PS groups

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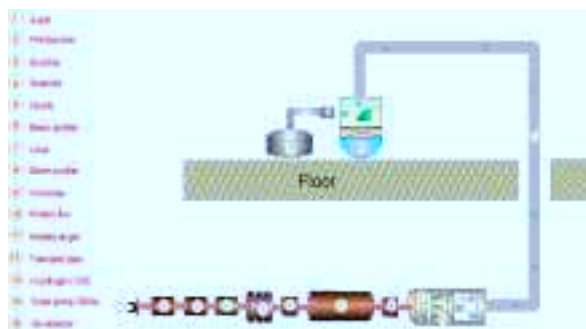
1 INTRODUCTION

The availability of intense neutron-rich ion-beams will open new perspectives in the study of nuclei very far away from the valley of stability. It would allow one to investigate the behaviour of nuclear matter under extreme conditions [1,2]. Several laboratories have concentrated their efforts in studies aimed at producing beams intense enough for the next generation of experiments (SPIRAL II and EURISOL). To produce such beams, a considerable R&D effort is required. Uranium fission is a very powerful mechanism to produce such radioactive beams. A substantial part of the PARRNe program (Production d'Atomes Radioactifs Riches en Neutrons) at the IPN Orsay is dedicated to the development of n-rich isotope beams by the ISOL (Isotope Separator On-Line) method. To produce the n-rich isotopes, fission induced by fast neutrons in a thick ^{238}U target has been investigated [3]. Yields of radioactive noble gases have been measured for different deuteron energies with the so called PARRNe-1 set-up in the framework of the European RTD program SPIRAL-II. The goal of the PARRNe R&D is the determination of the optimum conditions for the production of neutron rich atoms by the ^{238}U fission. An ISOL device PARRNe2 has been developed to carry out various R&D work [4].

2 INVESTIGATION OF PHOTO-FISSION PRODUCTION MODE

In order to probe neutron rich radioactive noble gases produced by photo-fission, a PARRNe-1 experiment has been carried out at CERN. The incident electron beam of 50 MeV was delivered by the LIL machine. This experiment allowed us to test the production of noble gases by photo-fission under the same conditions as during the previous PARRNe-1 experiments using fast neutrons. The incident electrons are slowed down in a W converter or directly in the target, generating Bremsstrahlung γ -rays which may induce fission. In the photo-fission method proposed by Diamond [5], nuclei are excited by photons at the Giant Dipolar Resonance (GDR). It is well known that the fission cross section at the GDR energy is 0.16 barn for ^{238}U (against 1.6 barn for 40 MeV neutrons induced fission) but the electrons/ γ photons conversion efficiency is much more significant than that of deuterons/neutrons. Estimations indicate that 3×10^{13} fissions/s could be produced in an optimal ^{238}U target using a 100 kW beam of 30 MeV electrons which is about the optimum energy for this production mechanism.

PARRNe-1 has been designed to be compact and portable to enable its installation at various accelerators. The search of the optimal energy of the deuterons was done by installing this set-up successively at IPN Orsay (20 MeV) [6], at CRC Louvain La Neuve (50 MeV) and at KVI Groningen (80 and 130 MeV) [7]. In the following we will concentrate on the photo-fission experiment. The PARRNe-1 set up consists of measuring the activity of produced radioactive noble gases by trapping them on a cold finger (13°K) in front of which is placed a Germanium detector (figure1). The cold finger is connected to the target by an 8 meter long tube at room temperature. This device allows one to shield the detection system from the irradiation point. The target is composed of 67 disks of ^{238}UCx of 14 mm diameter and 1mm thickness. The contained ^{238}U quantity in the target is 23 g. The target is heated to 2200 °C within a graphite container which is placed inside a graphite oven. All other elements produced are condensed at the entrance of the long tube.



field gradient [11]. The section is composed of 135 elementary cells assembled by silver diffusion type brazing. The whole is placed inside a stainless-steel vacuum envelope. This section provides an energy gain of 46 MeV for only 11 MW input RF power. For the beam matching to the section, one solenoid and one quadrupole triplet are inserted between the buncher and the accelerating cavity. Recently, transmission tests of a similar section have been performed at CLIO [12]. They have shown the same transmission through the structure with and without the surrounding solenoid field.

3.2 RF System

The system is based on the use of a Thalès klystron (TH2100) and a modulator from LAL (figure 4). The 3 GHz klystron which has 5 integrated cavities delivers a 4.5 μ s long RF pulse and provides a peak power of 35 MW. The average power is about 17 kW. The linac operation requires only 20 MW, therefore a fraction of the nominal power (30 W) delivered by the system would be used to test new RF components designed by the group in the framework of accelerator R&D. The RF power is distributed by a waveguide network (WR 284) under SF₆ gas as dielectric medium at a pressure lower than 6 bar. The power and the phase at the pre-buncher and the buncher are adjusted by inserting attenuators and phase shifters.

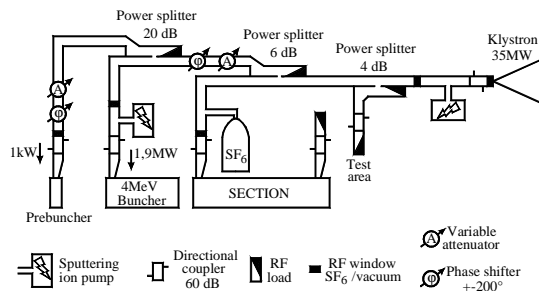


Figure 4: Power RF network

3.3 The Beamline

The designed beam line consists of two 65° dipole magnets ($R=0.4$ m) and seven magnetic quadrupoles (figure 5). The first quadrupole triplet placed behind the accelerating section allows the control of the beam envelope at the entrance of the first dipole. To achieve the achromaticity of the deviation, a quadrupole is placed between the two dipoles. The beam dimension is adjusted on the PARRNe target using the last quadrupole triplet. The beamline will be equipped with beam diagnostics: measurement of current, beam position, energy and energy spread.

3.4 Vacuum System

The vacuum system is composed of six 240 l/s sputter ion pumps. At the entrance of the RF cavities the network is pumped by two 70 l/s sputter ion pumps. The linac is maintained at a residual pressure lower than 10^{-7} mbar. The upper pressure limit in the gun is 2×10^{-8} mbar. The

whole vacuum system is controlled by a Siemens automat.

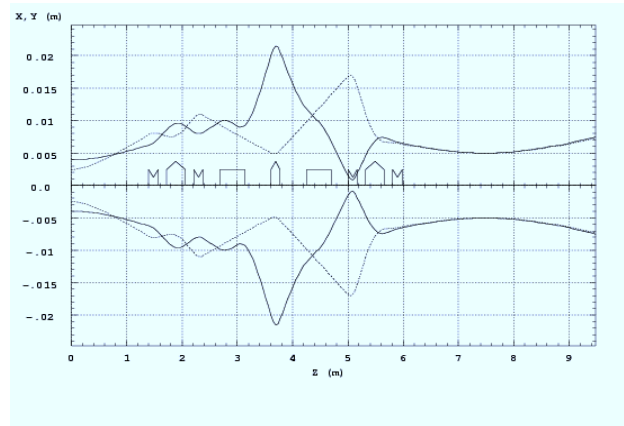


Figure 5: Beam transport calculations

4 CONCLUSION

The installation cost of ALTO is estimated to be 1.4 ME without including the cost of the LIL front end (from CERN), the RF system (from LAL), and all the infrastructure and manpower (from IPNO). After acceptance of the financial plan before the end of 2002, the ALTO project schedule will be extended to a maximum period of 18 months. The use of ALTO will open experimental applications in different fields such as biology, biochemistry, industry, accelerator R&D for the test of newly developed cavities and diagnostic instrumentation.

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